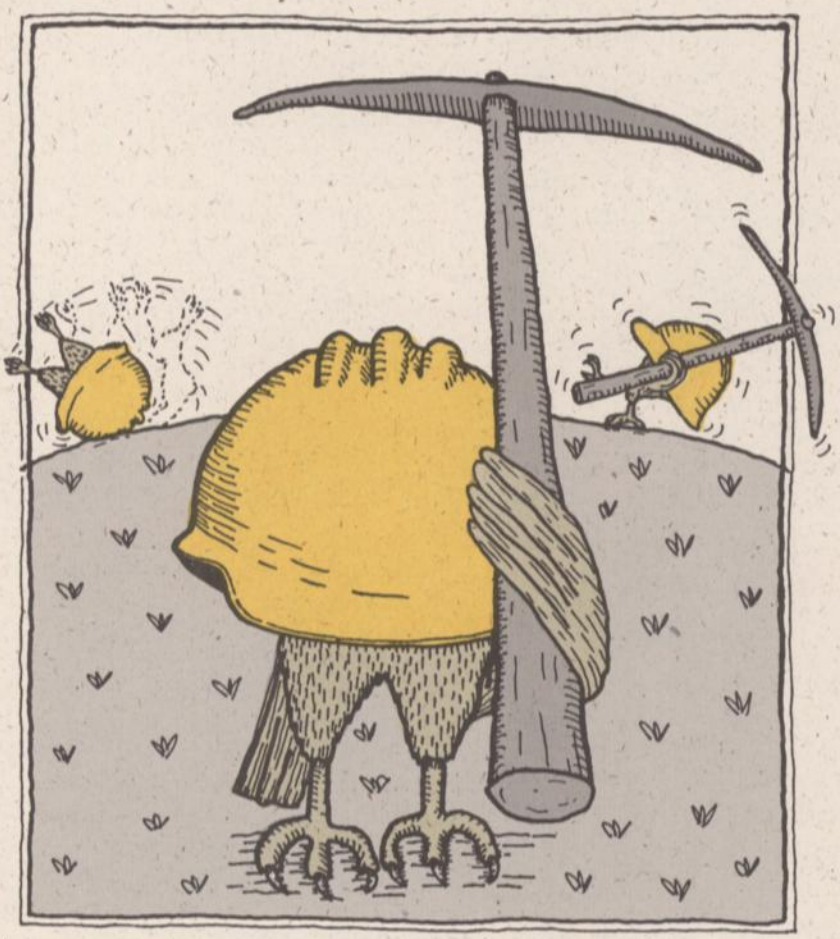
LITE geology

A quarterly publication for educators and the public–contemporary geological topics, issues and events

New Mexico Bureau of Mines and Mineral Resources (NMBM&MR)



Mining is for the birds

This Issue:

Earth Briefs

Mining is for the Birds

(Raptors, that is)

If you were a red-tailed hawk searching for a nice neighborhood to raise some chicks, where would you settle? How about a narrow ledge on the highwall of an active, surface coal mine in New Mexico? That is exactly where one persistent red-tailed hawk and her mate chose to roost at the Pittsburg & Midway (P&M) Coal Company's McKinley mine north of Gallup, New Mexico. In the spring of 1995, a pair of red-tailed hawks found a ledge on the mine-pit highwall, built nests, and moved in to raise a family. Because they are federally protected, raptors, or birds of prey, may not be disturbed while nesting unless it interferes with mining. In that case P&M can obtain special permits to relocate the birds.

Attempts to discourage the hawks' choice of nesting sites by installing tarps and fencing on the ledge failed. First, the hawk laid a batch of eggs that were relocated to Albuquerque for hatching. A few months later the pair built a second nest nearby and because mining was not immediately affected, were allowed to hatch some chicks. On both occasions P&M employees obtained permits from U.S. Fish and Wildlife Service and permission from the Navajo Nation to relocate the set of eggs and the new chicks. A group called *Hawks Aloft* removed both the eggs and the chicks in separate hair- and feather-raising rappeling trips down the face of the highwall. *Wildlife Rescue* cared for the first and second sets of babies until they were old enough to be on their own.

P&M is required to conduct raptor surveys on the mine site to determine whether there are any negative impacts from mining. Environmental

specialists working at P&M's McKinley mine conduct aerial and walking surveys of the raptor populations. Ron Wise, P&M's senior environmental specialist, says that raptor populations at the mine have been increasing, which indicates that the reclamation programs are working well.

Reclamation experts consider raptors to be good indicators of the health of the wildlife community at a mine site. Raptors, including owls, eagles, hawks, and falcons, feed at the top of the food chain. Their presence demonstrates that other species along the food chain, such as rodents and snakes, are thriving as well.

Another group, *Hawk Watch International,* is concerned with preserving birds of prey. Members band raptors with I.D. tags and monitor their health. Most of the funding for these preservation efforts comes from mining companies and from dwindling federal sources.

Sources:

Raptor Attention (Briefings): Mining Voice, National Mining Association, vol. 2, no. 1, p. 8.

Highwall nest-egg hawks fly free: Prime Miner, Pittsburg and Midway Coal Company, Englewood, Colorado, Fall 1995, pp. 1, 4.

For information on raptor protection, contact:
HawkWatch International
P.O. Box 660
Salt Lake City, UT 84110
(801) 524–8511

HawkWatch International publishes *Raptor Watch, a* newsletter sent to all members of the organization. Contact them to learn more about their activities to monitor and promote the conservation of birds of prey.

—story by S. Welch

Have You Ever Wondered...

...How volcanologists help solve environmental problems?

Nelia Dunbar
Geochemist, NMBM&MR

In-situ vitrification: Artificial magmas that help protect the environment

How can scientists use their knowledge of volcanoes to make radioactive waste safer? The answer is by using **in-situ vitrification**, *a process that allows people to create a* **magma**, *or molten rock, similar to that which erupts from an active volcano, from soils that are contaminated with dangerous metals or radioactive elements.*

In some areas of the United States, and the rest of the world, radioactive and other dangerous elements that are by-products of industrial processes have been stored in pits dug in soil. However, these pits do not always provide a good long-term storage solution because the elements may leak, or migrate, out of the pit and contaminate local drinking-water supplies. Simply digging up the radioactively contaminated soil can be problematic because disturbing the soil can cause more migration of the harmful elements into drinking water, and there is the further problem of finding a place to put the contaminated soil.

Researchers have devised a unique and creative way to stop the migration of radioactive and other dangerous elements away from contaminated soil areas. The method is to melt the soil in place, forming a magma, and then allow the magma to cool quickly into a volcanic-type rock that traps the dangerous elements for many thousands of years. The process is called **in-situ vitrification** or the abbreviation **ISV**. Because the contaminants remain in place, they are stabilized and prevented from moving for a very long time.

ISV is particularly well-suited to disposal of certain radioactive elements, such as ^{90}Sr (strontium) and ^{137}Cs (cesium), which have relatively short **half-lives**. The half-life of a radioactive element is the time during which 1/2 of the atoms decay to form stable atoms. The decay of a radioactive element is a spontaneous transformation of the unstable nucleii of the atom, releasing a high-energy particle that can be harmful to living organisms. The end result, though, is a non-radioactive, or stable atom, that is not harmful. The half lives of ^{90}Sr and ^{137}Cs are 29 and 30.17 years, respectively, so over several thousand years, almost all of the radioactive Sr and Cs will have decayed to stable atoms.

The ISV process

ISV uses 4 large cylindrical electrodes, up to 30 cm in diameter, that are placed vertically on the ground in a square configuration (see Fig. 1) over the contaminated soil area. Then a powerful current is fed

to the electrodes. This current causes electrical-resistance heating of the soil between the electrodes and the soil becomes hot enough to melt. Melting occurs when the soil reaches temperatures of about 1000° Celsius (~1770° Fahrenheit). Once the melting begins, the electrodes move downwards through the molten soil under the force of gravity, and cause more melting to occur. Eventually, over a period of several days, or even weeks, a large body of extremely hot magma is formed. The magma appears red and bubbly, just like that observed in Hawaiian volcanoes.

The temperature of the magma can be controlled by adjusting the amount of power that is fed to the electrodes. Very hot temperatures, above 1400°C (2550°F), are best because a hotter melt undergoes more **convection**, the type of circulation and mixing that can be observed in a boiling pot. Mixing of the magma is important for the most even distribution of the contaminant elements. ISV magmas that weigh as much as 10 tons have been made (Jacobs et al., 1992), and much larger ones will be planned for the future. ISV has been applied to contaminated sites around Hanford, WA and a few other areas of the United States.

The gas plume that can be observed issuing from active volcanoes contains mostly water and carbon dioxide (CO_2). However, elements, such as chlorine (Cl), fluorine (Fl), sulfur (S), lead (Pb), mercury (Hg), and others also are present in volcanic plumes (e.g. Symonds et al., 1990). Some of these elements, if emitted to the atmosphere, can cause air pollution. Researchers realized that the gas emitted from ISV magmas, like natural magmas, could contain some of these elements, and this was confirmed by measurements (Dunbar, 1992). In order to contain these gasses, all ISV magmas are covered with a metal structure, and all gasses emitted during active melting are filtered to remove polluting elements before being emitted to the atmosphere.

Once an ISV magma has reached its final size, the power to the electrodes is turned off, and the magma body is allowed to cool naturally. During this cooling process, the contaminant elements are frozen in place as the magma solidifies, and are no longer able to leak away and migrate into local water supplies. A number of scenarios can occur as the magma cools, depending on the chemical composition of the magma and how fast it cools. First, the magma may cool quickly to form glassy material that looks just like volcanic obsidian (Fig. 2). The contaminant elements will be dissolved in the glass and frozen there, like dust frozen into a block of ice. However, unlike ice, the obsidian-like glass will not melt and release the contaminants unless it is reheated again to extremely high temperatures.

Contaminants could be removed selectively from the glass without

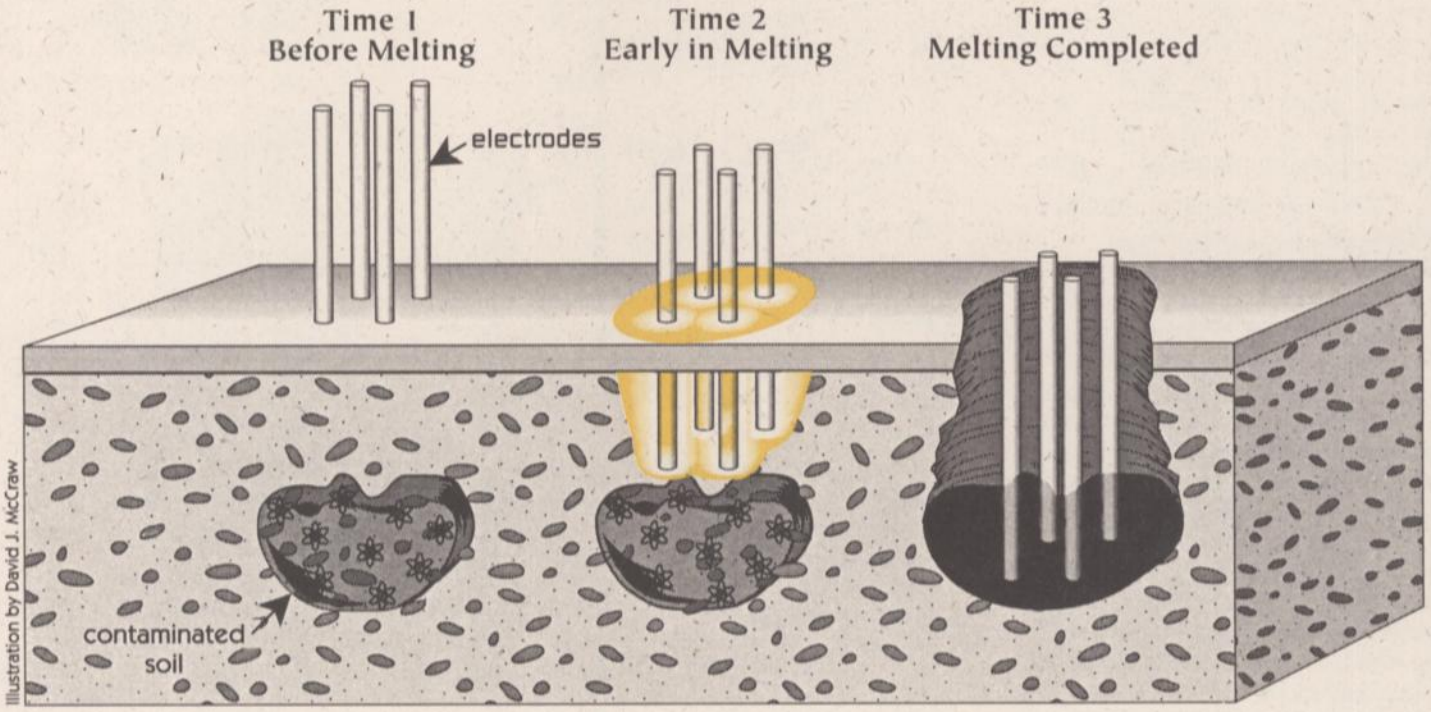


Figure 1—Diagram of the evolution of an ISV magma.

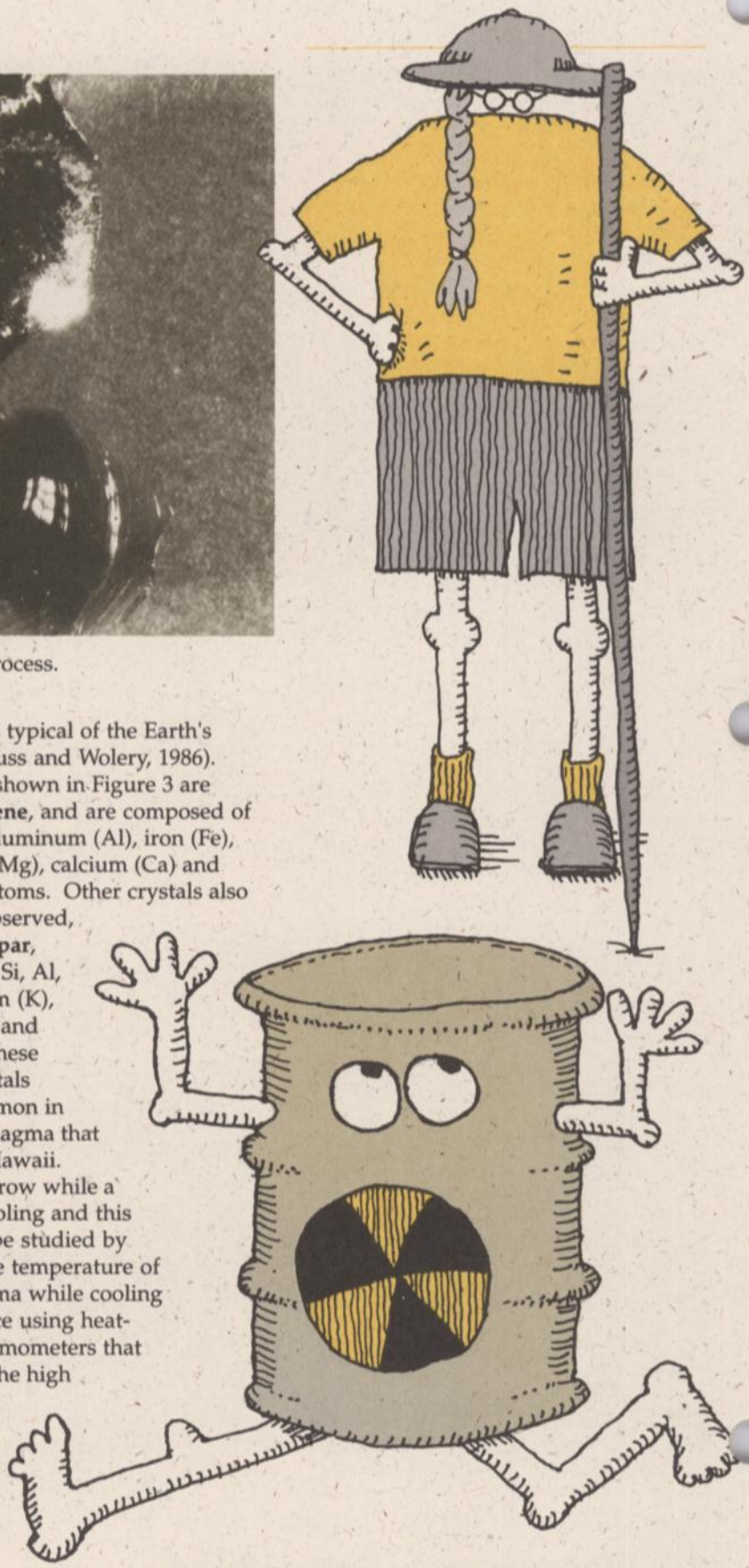
Figure 2. Photograph of glass produced from the ISV process.

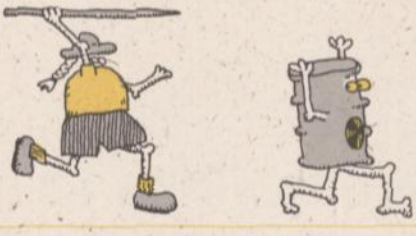
actual melting if chemical alteration, termed leaching, took place by water coming in contact with the glass. However, researchers working on natural volcanic glass or artificial glass know that this type of leaching occurs at very slow rates, and would not consider this to be a problem for ISV glass (McGrail and Olson, 1992).

What can be learned from ISV

Certain chemical compositions of ISV magma will not just form obsidian-like glass, but will grow crystals during cooling. This process is interesting to geologists because the crystallization in ISV magmas may be similar to crystallization that forms some types of rocks, such as granite. An example of crystals formed in a cooled ISV magma can be seen in Fig. 3. The contaminant elements can become trapped in the crystal during cooling, similar to the way in which they are trapped in the glass, and will not be released unless the crystal is remelted, or is chemically dissolved, or leached. Significant chemical dissolution of crystals is a process that has been shown only to occur over a period of many thousands of years at temperatures typical of the Earth's surface (Knauss and Wolery, 1986). The crystals shown in Figure 3 are called **pyroxene**, and are composed of silicon (Si), aluminum (Al), iron (Fe), magnesium (Mg), calcium (Ca) and oxygen (O) atoms. Other crystals also have been observed, such as **feldspar**, composed of Si, Al, Ca, potassium (K), sodium (Na) and O. Both of these types of crystals also are common in the type of magma that is found in Hawaii.

Crystals grow while a magma is cooling and this process can be studied by observing the temperature of the ISV magma while cooling is taking place using heat-resistant thermometers that can survive the high temperatures of the magma. Growth of crystals is an





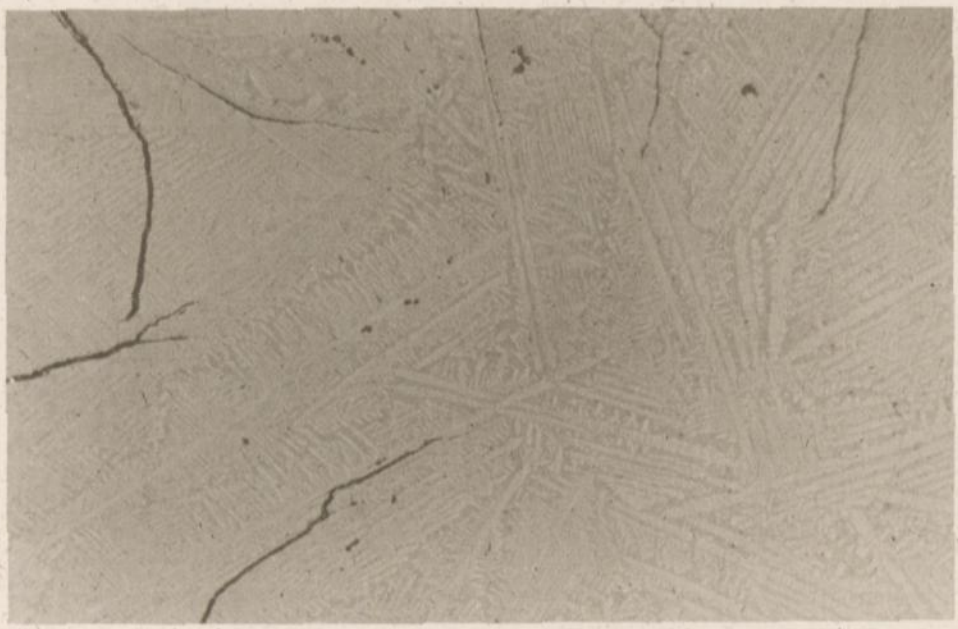


Figure 3—Photograph of crystals grown in an ISV magma. The photograph was taken with a microscope, and the width of the photograph is 1 millimeter. The light-colored areas are the pyroxene crystals, and the darker background is the surrounding glass.

exothermic process, meaning a process that releases heat when it occurs. Researchers have been able to observe the heat related to crystallization, and an example of one observation is shown in Figure 4. These temperature data for an ISV magma shows that as soon as the electrode power is turned off, the ISV magma begins to cool very rapidly, but when it drops to a temperature of around 1170°C (2048°F), cooling of the magma ceases for a period of time.

Researchers had predicted that this type of thermal effect might occur in large cooling magma chambers, but had not been able to observe this behavior because real magma chambers are located deep in the Earth's crust, and their temperatures cannot be monitored. The observations made during the ISV process will allow better understanding of the behavior of large bodies of magma by being better able to predict their cooling histories.

Using in-situ vitrification gave scientists an opportunity to apply what they have learned from studying volcanoes to solve an environmental problem. At the same time, the small and controlled ISV magma body has provided a unique chance to study more about processes related to volcanoes.

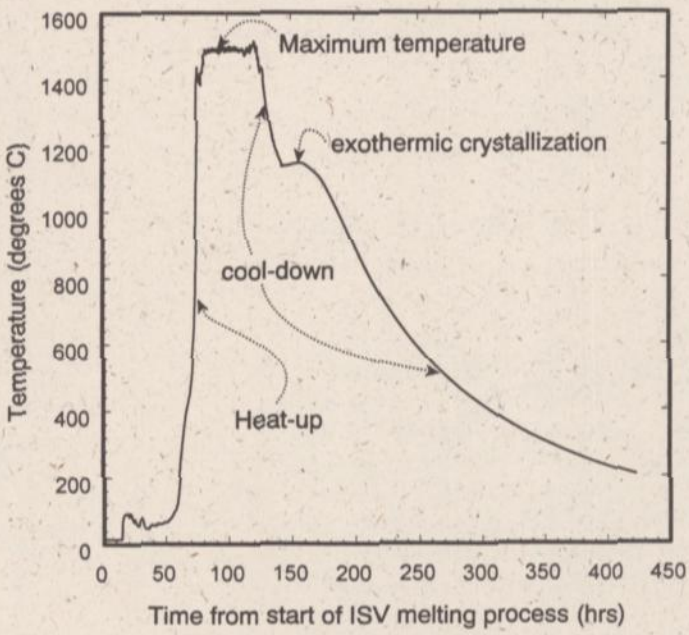


Figure 4—Variations in the ISV magma temperature through time. The power to the electrodes was turned on at time 0. Following the "power-on" time, the area goes through a heat-up stage with melting beginning at around 1000°C. The magma was held at temperatures greater than 1400°C for the duration of time needed for all the contaminated soil to be included in the magma (see Figure 1). Once the final size is reached, "cool-down" begins.

References

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McGrail, B. P. and Olson, K. M. , 1992. Evaluation of long-term performance of In Situ Vitrified waste forms: methodology and results. Pacific Northwest Laboratory report 8358, pp 1–44.

Symonds, R. B., Rose, W.I., Gerlach, T.M., Briggs, P.H., and Harmon, R. S., 1990. Evaluation of gases, condensates, and SO_2 emissions from Augustine volcano, Alaska: The degassing of a Cl-rich volcanic system. Bull. Volcanol., 52, pp. 355–374.

Scenic Trips to the Geologic Past...

In addition to Lite Geology, *the New Mexico Bureau of Mines and Mineral Resources publishes a series called* **Scenic Trips to the Geologic Past** *that features day-trip tours of geologically interesting areas in New Mexico. Geologic and social history is featured along with road logs keyed to driving and sometimes boating, railroading, horseback riding, or hiking. The road logs describe points of interest along the highways and byways of the state.*

The series currently includes 16 titles, some with regional emphasis and some with state-wide interest. Regional books cover the Taos area (2 different books), Ruidoso, T or C and Elephant Butte area, Pecos Wilderness, Southwestern New Mexico (Silver City, Deming, Lordsburg), Cumbres and Toltec Railroad, Albuquerque, and Santa Fe. The following is an excerpt from the most recently published trip, **A Trip Through Space and Time—Las Cruces to Cloudcroft**. *The text and photos appear in the social history section near the beginning of the book.*

excerpts from Scenic Trip 15,
text from pages 31–34

A Trip Through Space and Time

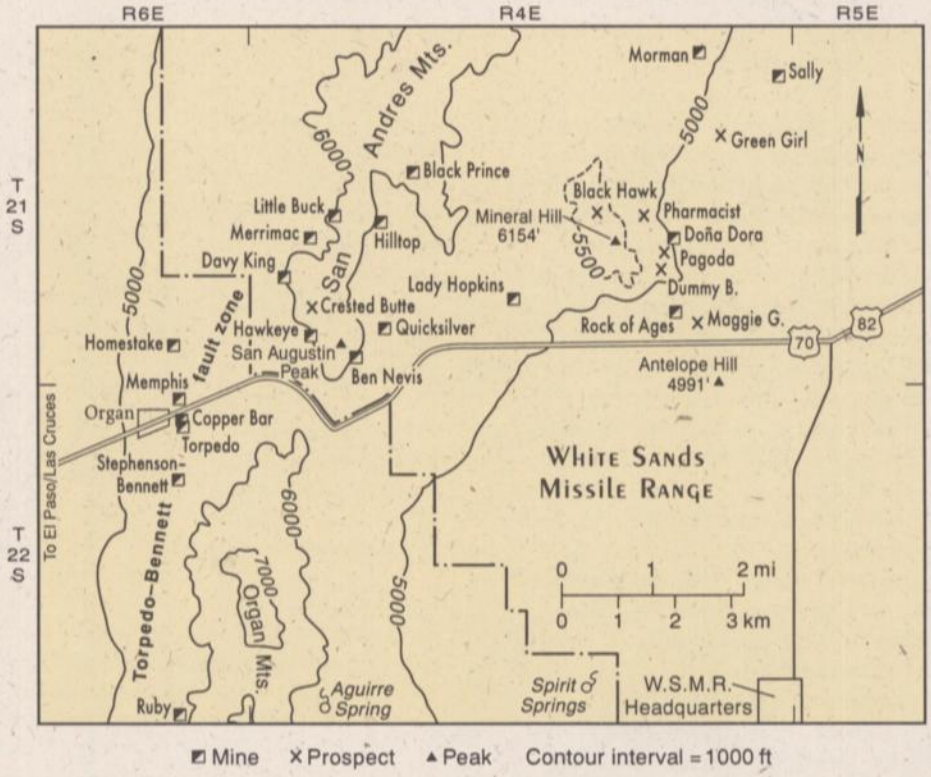
by Russell E. Clemons

Soldiers, prospectors, and miners

The Stephenson mine was first discovered and worked by Jose Perez, Alejo Carrasco, and Jose Blas Duran in 1849. Then it was named the Santo Domingo de las Calzadas (Eveleth, 1983). Hugh Stephenson became a partner and later, by devious means, sole owner of the mine. He sold the mine for $12,500 in 1858 to several army officers stationed at Fort Fillmore. The mine was confiscated by the Confederates in 1861 (Jones, 1968). There was little other mining activity in this part of the state until after the Civil War.

The Civil War was brief in southern New Mexico. On July 23, 1861, Confederate Lt. Colonel John R. Baylor marched up the Camino Real from old Fort Bliss with his 2nd Regiment of Texas Mounted Rifles and several independent companies, totaling about 300 men. They were welcomed in Mesilla and took peaceable possession July 25. That afternoon, Union Major Isaac Lynde led about 380 men toward Mesilla from Fort Fillmore, 6 miles away but was driven off by Baylor's troops. Lynde started to fortify Fort Fillmore but decided instead to abandon the Fort and retreat toward Fort Stanton, northeast of present-day Ruidoso, by way of San Augustin Pass. The Confederates soon took pursuit and caught up at San Augustin Springs, on the east slope of the pass. Lynde apparently did not believe that he could win, so he surrendered on July 27, 1861, despite the protests of his officers. Fort Fillmore remained in Confederate control for almost a year; they also held Fort Stanton briefly and Fort Thorn, north of Hatch. Confederate troops left New Mexico July 8, 1862 (Wilson, 1975).

Following the war, difficulties proving ownership of the Stephenson mine, claim jumping, litigation, and Apache hostilities delayed mining in the Organ district. The first survey for patented claims was run in 1871 and a second, in accordance with the new mining laws of 1872, was made in 1883. Arrival of the railroad in 1881 stimulated prospecting and mining. The Memphis, Merrimac, Hawkeye, and Black Hawk deposits were discovered by 1882. The Bennett lode was combined with the Stephenson mine in 1887 to become the leading producer of lead and silver in the



Map of mines in the Organ mining district. Mineral Hill is the most probable location of the Lost Padre Mine (map was modified from Kelly, 1975: New Mexico Geological Society Guidebook 26; also from personal communication with V. T. McLemore, 1995).

Little Buck mine, Organ mining district, circa 1890. Photo courtesy of the Rio Grande Historical Collections, New Mexico State University Library (from page 34, NMBM&MR Scenic Trip 15).

district.

Another 30-40 mines and prospects of gold, silver, copper, lead, and zinc were discovered before the turn of the century. These included the Modoc mine, on the west side of the Organ Mountains about 6 miles south of Organ, which was active by 1879. Activity in Gold Camp, about 6 miles east of Organ, began in 1883 with a gold rush of about 1000 people encamped there until 1893 (Dunham, 1935). Organ was born when the Torpedo mine started producing copper and silver in 1899. Stagecoach service was provided from El Paso along the east side of the Franklin and Organ Mountains. A post office was established at Kent, in Gold Camp, on July 13, 1904. It was abandoned in 1911 as activity declined. Minor recovery periods occurred periodically for many years, but the "good ole days" had passed. Fluorite mines on Tortugas Mountain (A Mountain) opened in 1920 and operated for about 12 years.

Prospectors started arriving in the Jarilla (small bushes) Mountains, 30 miles east of Organ, in 1879, and gold was found by 1887. Most of the settlement, known as San Augustin and also as "East Organ," had grown at San Augustin Springs and moved "locks, stocks, and saloon" to Orogrande by the turn of the century (Herman Weisner, oral comm., 1988). Turquoise was discovered about 1897 by Amos DeMueles. As miners arrived, settlements formed, and a post office was established at Jarilla March 17, 1899. The name was changed to Brice in 1904, and mail service transferred to Orogrande in 1909. A second post office was established at Jarilla Junction (on the El Paso and Northeastern Railroad) September 2, 1905. Its name was changed to Orogrande in 1906 after George Moffett found a "big gold" nugget in the nearby mountains. A 6.5 oz nugget, valued at $123.00, was mined in June 1904 (Jones, 1968). A third company town, Ohaysi (Indian, "hidden") had a post office from November 28, 1916 to 1921 before its service also was transferred to Orogrande.

Early Orogrande had a population of 2,000 as 16 tent-hotels and nine saloons flourished. Some of the hotel beds were rented to both day and night mine workers! It is claimed that the mines produced $1 million in gold, silver, and turquoise between 1905 and 1913. Other estimates are as low as $100,000 (Howard, 1967). During this period mining of copper and iron ores also began but ended soon after World War I. Adequate fresh water has always been a problem for Orogrande, whose present supply comes from high in the Sacramento Mountains.

John Dodd (left) and Louis Bentley panning for gold in Texas Canyon, circa 1903. Photo courtesty of the Rio Grande Historical Collection, New Mexico State University Library, from p. 95, NMBM&MR Scenic Trip 15.

Mill below Modoc mine, circa 1903. Photo courtesy of the Rio Grande Historical Collections, New Mexico State University (from page 32, NMBM&MR Scenic Trip 15).

Louis Bently, assayer, Organ, New Mexico, circa 1900. Photo courtesy of the Rio Grande Historical Collections, New Mexico State University (from page 35, NMBM&MR Scenic Trip 15).

Scenic Trips to the Geologic Past

ST-2	**The Enchanted Circle—Loop drives from Taos,** by P. W. Bauer, J. C. Love, J. H. Schilling, and J. E. Taggart, Jr., fifth edition, revised, 1991, 137 pp.	7.50
ST-3	**Roswell-Ruidoso-Valley of Fires, including trips to Lincoln, Tularosa, and Bottomless Lakes State Park,** by J. E. Allen and F. E. Kottlowski, third edition, 1981, 96 pp.	5.25
ST-4	**Southern Zuni Mountains, Zuni—Cibola trail,** by R. W. Foster, third edition (completely revised), 1971, reprinted 1984, 75 pp.	2.25
ST-6	**Trail guide to the upper Pecos,** by P. K. Sutherland and A. Montgomery, third edition (completely revised), 1975, reprinted 1981, 1989, 114 pp.	6.50
ST-8	**Mosaic of New Mexico's scenery, rocks, and history,** edited by P. W. Christiansen and F. E. Kottlowski, third edition, 1972, reprinted 1982, 1988, 170 pp.	4.25
ST-10	**Southwest New Mexico,** by R. E. Clemons, P. W. Christiansen, and H. L. James, second edition (completely revised), 1980, 119 pp.	4.25
ST-11	**Cumbres and Toltec Scenic Railroad,** by H. L. James, 1972, 73 pp.	3.25
ST-13	**Española-Chama-Taos—a climb through time,** by W. R. Muehlberger and S. Muehlberger, 1982, 99 pp.	4.75
ST-14	**The Story of Oil in New Mexico,** by P. W. Christiansen, 1989, 112 pp.	5.25
ST-15	**A Trip through Space and Time—Las Cruces to Cloudcroft,** by R. E. Clemons, 1996, 194 pp.	12.00
ST-16	**Elephant Butte-Eastern Black Range Region,** by R. P. Lozinsky, R. W. Harrison, and S. H. Lekson, 1995, 169 pp.	8.00

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Scenic Trips to the Geologic Past

Traffic jam on the Las Cruces–Organ road, circa 1915. Photo courtesy of the Rio Grande Historical Collections, New Mexico State University (from page 99, NMBM&MR Scenic Trip 15).

Sources for Earth Science Information

A free teacher's packet including a poster, lesson plans, activities, and a list of mineral resource information can be obtained by calling or writing to:

Mineral Information Institute
Jackie Evanger
475 17th Street; Suite 510
Denver, CO 80202
(303) 297–3226

Information on Earth science programs, projects, reports, products and their sources is available from:

US Geological Survey
Earth Science Information Center
(USGS ESIC)
Call 1–(800) USA–MAPS

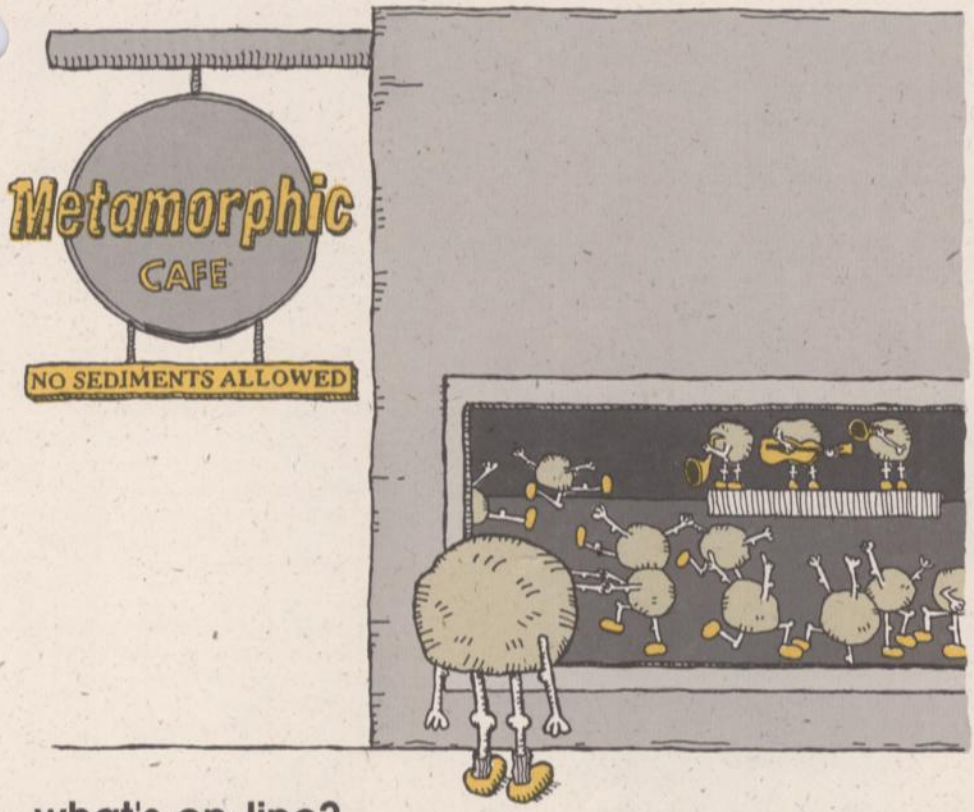
or in New Mexico, contact:

Amy Budge
Earth Science Information Center
Earth Data Analysis Center
University of New Mexico
Albuquerque, NM 87131
(505) 277–3622

Information on earthquakes in New Mexico is available by contacting:

Bob Redden
Program Manager
New Mexico Earthquake Preparedness Program
Department of Public Safety
P.O. Box 1628
Santa Fe, NM 87504
(505) 827–9254

note: Please mention *Lite Geology* as the source when contacting the above sources. Thanks!–ed.



upcoming events...

BHP Minerals of Farmington sponsors its Third Annual Minerals Education Workshop
August 8–10, 1996
Teachers from around New Mexico are invited to attend the third annual workshop sponsored by BHP Minerals. Participants will learn hands-on activities to teach students about geology and mining. There will be field trips to one of BHP's mines and a power plant, along with a field trip to southwestern Colorado to study historic mining sites. The course and the materials are FREE. Graduate credit is available; participants are responsible for the cost of tuition for credit. To register, please contact Teri Conrad, BHP Minerals, P.O. Box 561, Waterflow, NM 87421; or call (505) 598–2019 (at work); or (505) 327–6587 (at home). Hope to see you there!

what's on-line?

Volcanic Eruption Simulator Software Downloads for FREE
Some Windows/DOS volcanic eruption software from Los Alamos can be downloaded free from the Rockware web site at:

http://www.aescon.com/rockware/index_fr.html

ERUPT is a graphical program that simulates various volcanic eruption types,including Strombolian, Plinian, pyroclastic flows and surges, fluid lava flows, and viscous lava dome emplacement. Tectonic (faulting), sector collapse, and erosional events are also simulated. Winerupt is the Windows version and Doserupt is the DOS version.

***Lite Geology* evolves:**
Lite Geology began as a small Earth-science publication designed and scaled for New Mexico. Our subscription list now includes a large number of out-of-state readers. In order to keep up with the demand for this publication from outside of New Mexico, we now charge **$4.00 per year for out-of-state readers**, which covers the cost of printing and mailing. The subscription year begins with the Fall issue, and ends with the Summer issue to correspond with the academic year. **If you reside outside of New Mexico and wish to keep your subscription active, please return this form with a check for $4.00.** If you have questions, please call Theresa Lopez at (505) 835-5420.

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**Beginning with the Fall 1994 issue, out-of-state subscribers will be charged $4.00 per year to cover printing and mailing costs.

Teacher training on earthquakes continues!

Tremor Troop: September 30–October 2, 1996

The **second** in a series of four workshops for teachers on earthquakes will be held in early fall. *Tremor Troop* will be held in Los Alamos and is designed for teachers of grades K–6. This curriculum features multidisciplinary, hands-on classroom activities designed to promote literacy and provide young children with an understanding of earthquakes and other earth science projects. The curriculum was developed by National Science Teachers Association (NSTA) for the Federal Emergency Management Agency (FEMA). Lots of fun activities and a local field trip are included. New Mexico *Tremor Troop* will include a special volcanic hazards section developed by NMBM&MR. The workshops are free, and travel and per diem are available if participants travel more than 30 miles to attend. Reimbursement for substitute pay is available as well. For more information, or to register, call Bob Redden, New Mexico Department of Public Safety at (505) 827–9254; or call Susan Welch, NMBM&MR, at (505) 835–5112.

Note: The first workshop in this series, *Seismic Sleuths*, was held in May of this year in Socorro and was a huge success! Thanks to all of the teachers who participated and thanks to the course instructors, Bill Chavez (NM Tech), Dave Love, and Nelia Dunbar (NMBM&MR), Sue Abbott (Sarracino Middle School), and Sue Baranchick (La Mesa Elementary School) for their hard work. What fun we all had! Teachers who haven't signed up for one of the three remaining workshops still can do so. Contact us soon as space is limited. We will be bringing *Seismic Sleuths* to Albuquerque in late fall 1996 and *Tremor Troop* to Las Cruces in February 1997.

Lite Geology is published quarterly by New Mexico Bureau of Mines and Mineral Resources (Dr. Charles E. Chapin, *Director and State Geologist*), a division of New Mexico Tech (Dr. Daniel H. Lopez, *President*).

Purpose: to build Earth Science awareness by presenting educators and the public with contemporary geologic topics, issues, and events. Use *Lite Geology* as a source for ideas in the classroom or for public education. Reproduction is encouraged with proper recognition of the source.

Lite Geology **Staff Information**
Editor: Susan J. Welch; susie@mailhost.nmt.edu
Geological Editors: Dr. Dave Love, Dr. Charles Chapin, and Gretchen Hoffman
Graphic Designer: Jan Thomas
Cartoonist: Jan Thomas with inspiration from Dr. Peter Mozley
Editorial Assistant: Toby Click
Creative and Technical Support: NMBM&MR Staff

Mailing Address
New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801. Phone (505) 835-5420. For subscription information, please call or write. *Lite Geology* is printed on recycled paper.
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LITE geology
New Mexico Bureau of Mines
and Mineral Resources
New Mexico Tech
801 Leroy
Socorro, NM 87801

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